THE COMPARATIVE RESISTANCE OF THREE BREEDS OF CHICKENS TO THE NEMATODE ASCARIDIA LINEATA (SCHNEIDER)

by

IVAN PRATT

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TABLE OF CONTENTS

INTRODUCTION

Resistance to disease is the reaction of a plant or animal which tends to destroy and eliminate invading organisms whether they be bacteria, fungi, protozoa or helminths. The physiochemical nature of the resistance to metazoan parasites is still unknown, although many attempts have been made to determine it and to produce the resistance artificially.

A number of host-parasite relationships have been studied in which the immature host gains with age a greater ability to eliminate the parasite. This has been called age resistance.

Looss (1911, p. 240) puts forward the fundamental idea underlying much of the subsequent research on the development of age resistance. He states, "... it may be that the juices and tissues of the body in the young individuals of every species of animal have not yet the specifically characteristic composition found in the adult. It is a well-known fact that animals which, when adult, have a marked odour, show no signs of this in youth; in the case of edible animals, the taste of the adult is so characteristic that the fully-grown individual can be recognized by it, but not so the young."

It is frequently observed that young chickens do not have the characteristic flavor of more mature ones; and likewise that they do not have the same odor. Whether or not this fact is related to age resistance is unknown.

The next work on resistance or immunity appears to have been that of Reuling (1919) who found that black bass developed a blood immunity to all species of Glochidia after having been infected once with a species.

In 1920, Ransom and Foster observed an age resistance to Ascaris in swine and the next year Ransom (1921) found age resistance in chickens infected with the "gape-worm" Syngamus trachea. During the same year Ackert and Herrick (1928) found that chickens infested with Ascaridia lineata displayed much greater resistance at four months of age than they did at one month. Subsequent studies by Herrick (1926) showed that the resistance increases as the chicken grows older. After 103 days no further increase was detected.

Demonstrations of age resistance by quantitative methods have also been made for Ancylostoma caninum in cats and dogs (Herrick, 1928; Scott, 1928; Sarles, 1929b); Ancylostoma braziliense in cats and dogs (Sarles, 1929a), and for Nippostrongylus muris in rats (Africa, 1931). Chandler (1932) discovered fewer Nippostrongylus in rats examined when 5 to 12 months old than in rats 4 to 10 weeks of age. However, he considered the difference of doubtful significance. Graham (1932) using a modified Stoll egg count method on the nematode, N. muris, found 14 week-old rats to be more resistant than those 6 weeks of age. Winfield (1933), using both egg count and size and number of worms at autopsy, demonstrated an age resistance of rats to Heterakis spumosa.

Many workers concur in the opinion that the diet of the host is an important factor in the development of resistance to the intestinal helminths. Ackert, Fisher and Zimmerman (1927) and Ackert, McIlvaine and Crawford (1931) found that reduction of vitamin A in the diet markedly lowered the resistance of chickens to the nematode Ascaridia lineata. This finding has been confirmed repeatedly. McCoy (1934) recently showed that rats deficient in vitamin A carried greater numbers of cysts of Trichinella spiralis than did normal rats.

Zimmerman, Vincent and Ackert (1926) and Ackert and Nolf (1931) found that a deficiency in vitamin B also reduced the resistance of chickens to A. lineata.

Some work has been done on the localization of immunity and on the serological basis of immunity to metazoan parasites.

Blacklock and Gordon (1927), working with the botfly Cordylobia anthropophaga and the guinea-pig as host, succeeded in making certain areas of the skin of the hosts immune to further infestation by the parasitic larvae. The immunity radiated outward from the seat of initial infestation. Their conclusion was that the immunity in this case was developed at the place where the parasite was located.

Blacklock, Gordon and Fine (1930) found that the fluid extracted from the haemocoele of third instar larvae of C. anthropophaga when injected into guinea-pigs caused an eosinophilia. Sandground (1928) thinks that eosinophilia does not play an important part in the mechanism of immunity and Blacklock and Gordon (1927) found no correlation between high eosinophilia and immunity.

The latter authors tested the blood of immune animals as a lethal agent for the botfly larvae. They found that the larvae died just as quickly in the blood of non-immune animals. Hyde and Bailey (1922) found that chickens did not respond to the injection of foreign red blood cells by an increase in the lytic power of the serum. Since chickens respond in development of immunity against nematodes similarly to animals which display increase in lytic power of serum, the immunity probably does not rest upon that point. Sandground (1928), using Strongyloides stercoralis to infect dogs and cats, found that the sera of immune animals does not confer passive immunity. But Herrick (1926) found that the blood serum of one cockerel increased the resistance of younger chickens when injected into them. He tried the serum of a number of other chickens, but obtained only negative results. Herrick suggests that this one cockerel was able to form antibodies, which ability was not shared

by any of the other birds from which serum was taken.

Sandground (1929) expressed the opinion that the turkey is the normal host of Ascaridia lineata, rather than the chicken and advanced this idea as an explanation of the age resistance which is found in the chicken. Experiments by Ackert and Eisenbrandt (1935), however, failed to show that A. lineata can live more successfully in the turkey than in the White Leghorn chicken.

The studies on the comparative resistance of chickens and turkeys to A. lineata raised the question of whether or not all breeds of chickens react similarly to the viability and growth of this intestinal worm. As all of the resistance studies in this laboratory were upon one breed of chickens, the Single Comb White Leghorns, it was proposed to compare the resistance of two other breeds of chickens to A. lineata with that of the White Leghorns. The other breeds selected were the Barred Plymouth Rocks and the Buff Orpingtons.

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appreciation is hereby made.

MATERIALS AND METHODS

Day old chicks purchased from a commercial hatchery were placed in the Animal House, a steam-heated, well-lighted and ventilated building. The ration which was hopper-fed consisted of the following[1]:

Yellow corn meal	40 gm.
Oatona (ground oats)	17 gm.
Alfalfa leaf meal	4 gm.
Meat meal	10.4 gm.
Powdered milk	6.4 gm.
Cracked wheat	15.0 gm.
Cod liver oil	1.69 gm.

When the chicks were 10 days old they were banded and separated into groups A, B and D. Weekly thereafter the chickens were weighed.

About the time the chicks were purchased, roundworms, Ascaridia lineata (Schneider), were procured for egg cultures. Large female worms were selected for this purpose. Each worm chosen was dissected and the uteri removed to a clean Petri dish. The walls of the uteri were pricked at various points and the escaping eggs examined microscopically for fertility. The portions of the uteri containing fertile eggs were subjected to slight pressure for the

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[1] Indebtedness is acknowledged to the Kansas State College Department of Poultry Husbandry for suggestions in preparation of the ration.

removal of the eggs which were then covered with distilled water containing 2 or 3 drops of 2 per cent formaldehyde added for fungus prevention.

The egg cultures in closed Petri dishes were incubated for at least 14 days at about 30° C. At the end of this period most of the eggs had developed into the coiled embryo or infective stage.

When the chickens were 12 days old, part of them (Group A) were each administered 50 ± 5 embryonated eggs of the nematode A. lineata. The eggs, which were counted in small culture drops with the aid of a microscope and mechanical stage, were wiped off the slide onto bits of filter paper. These were then placed deep into the esophagus of the chicken with forceps.

The parasites were allowed to develop for 3 weeks in the digestive tract of the chicken. At the end of this time the chickens were killed, the intestines flushed by the pressure apparatus of Ackert and Nolf (1929) and the worms collected. Lengths of the worms were obtained by projecting their shadows magnified six times onto onion skin paper and tracing the shadows. The tracings were then measured by means of a calibrated wheel so marked off as to reduce the measurements directly to millimeters[1].

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[1]The number and length of worms for each chicken were entered in Record Book XIV, page 132 and following.

The criteria for judging the resistance of each breed were the average number and length of worms per group under comparison. These data were assembled and sorted according to breed and age groups. The various sets of data were then subjected to biometrical analysis. The average number and length of worms from the different breeds of the same age were compared for differences in resistance between breeds. The worms from the groups of chickens of various ages within a single breed were compared to ascertain whether or not age resistance was developed.

When the difference between the means of two groups under comparison was 3 or more times the probable error of the difference, it was considered significant and not due to chance variation.

EXPERIMENTAL DATA

Experiment 1

The chickens used in Experiment 1 consisted of 108 White Leghorn, 70 Barred Plymouth Rock and 78 Buff Orpington chickens purchased as day old chicks from a commercial hatchery on September 24, 1933.

Group A Examined When 33 Days Old. When the chicks were 12 days old, 34 White Leghorns, 12 Barred Plymouth

Rocks and 11 Buff Orpingtons were parasitized each with 50 ± 5 embryonated eggs of A. lineata. After three weeks the chicks were killed and the nematodes collected. The data for number and length of worms for each breed were subjected to statistical analysis.

The White Leghorns averaged 10.0 worms per chicken and the Barred Plymouth Rocks, 16.25 worms, an actual difference of 6.25 worms, which was not significant (Table 1). The worms in the White Leghorns averaged 22.1 mm. in length while those in the Barred Plymouth Rocks averaged 17.48 mm., a difference of 4.62 mm. which was 12.09 times its probable error.

The Buff Orpingtons averaged 13.18 worms per chicken, which was 3.18 worms more per chicken than from the White Leghorns. The difference was not sufficient to be considered significant. The average length of worms in the Buff Orpingtons was 23.56 mm., which was 1.46 mm. longer on the average than in the White Leghorns. The difference was 3.74 times its probable error which is considered significant.

A comparison of the Barred Rocks and the Buff Orpingtons showed no significant difference in the number of worms. The average difference in length was 6.08 mm. which was significant (13.36 times its probable error).

Table 1. The comparative resistance of three breeds of chickens to the nematode Ascaridia lineata (Schneider). Data from Experiment 1. Chickens parasitized at 12, 19, and 33 days, respectively.

	Number of Worms							Length of Worms					
Chickens	Number of hosts	Average number worms per chicken	Standard deviation	Error of mean	Actual difference of means (D)	Probable error of difference (E)	Ratio, $\frac{D}{E}$	Average length of worms (mm.)	Standard deviation	Error of mean	Actual difference of means (D)	Probable error of difference (E)	Ratio, $\frac{D}{E}$
Group A													
White Leghorns	34	10.00	10.67	1.24	6.25	2.85	2.19	22.10	5.80	0.21	4.62	0.38	12.09
Barred Rocks	12	16.25	13.19	2.57				17.48	6.57	0.317			
Buff Orpingtons	11	13.18	15.61	3.17	3.18	3.4	0.94	23.56	5.85	0.328	1.46	0.39	3.74
White Leghorns	34	10.00	10.67	1.24				22.10	5.80	0.212			
Barred Rocks	12	16.25	13.19	2.57	3.07	4.08	0.75	17.48	6.57	0.317	6.08	0.46	13.36
Buff Orpingtons	11	13.18	15.61	3.18				23.56	5.85	0.328			
Group B													
White Leghorns	49	8.18	7.04	0.678	4.15	0.89	4.68	17.87	6.82	0.23	3.26	0.5	6.47
Barred Rocks	28	4.03	4.47	0.570				14.59	7.10	0.45			
Buff Orpingtons	27	4.37	5.87	0.762	3.81	1.02	3.74	16.68	8.26	0.513	1.19	0.56	2.12
White Leghorns	49	8.18	7.04	0.678				17.87	9.82	0.230			
Barred Rocks	28	4.03	4.47	0.57	0.34	0.95	0.36	14.59	7.10	0.45	2.09	0.68	3.06
Buff Orpingtons	27	4.37	5.87	0.762				16.68	8.26	0.513			
Group D													
White Leghorns	25	1.44	2.13	0.288	0.16	0.39	0.41	19.94	7.11	0.799	0.89	0.999	0.89
Barred Rocks	30	1.60	2.15	0.265				19.05	6.17	0.6			
Buff Orpingtons	40	1.97	3.02	0.322	0.53	0.43	1.23	18.22	7.96	0.604	1.72	1.0	1.72
White Leghorns	25	1.44	2.13	0.288				19.94	7.11	0.799			
Barred Rocks	30	1.60	2.15	0.265	0.37	0.42	0.89	19.05	6.17	0.6	0.83	0.85	0.98
Buff Orpingtons	40	1.97	3.02	0.322				18.22	7.96	0.604			

Group B Examined When 40 Days Old. Each one of 49 White Leghorn, 28 Barred Rock and 27 Buff Orpington chickens was parasitized at 19 days of age with 50 ± 5 embryonated eggs of Ascaridia lineata. Three weeks later the chickens were killed and the nematodes collected.

The White Leghorns had an average of 8.18 worms per chicken and the Barred Rocks an average of 4.03 worms; an actual difference of 4.15 worms per chicken, which was significant (Table 1). The worms in the White Leghorns averaged 17.87 mm. in length, while those in the Barred Rocks averaged 14.59 mm., a significant difference of 3.26 mm.

Upon comparing the Buff Orpingtons and the White Leghorns, it was found that the White Leghorns averaged 3.81 more worms than did the Buff Orpingtons, a significant difference (Table 1). The worms from the Buff Orpingtons averaged 16.68 mm. in length as contrasted to 17.87 mm. from the White Leghorns, a difference that was negligible.

A comparison of the Barred Rocks with the Buff Orpingtons showed that the Buff Orpingtons possessed an average of 4.37 worms apiece, the Barred Rocks 4.03 worms, a difference of only 0.34 worm. The worms from the Barred Rocks averaged 14.59 mm. in length, while those from the Buff Orpingtons averaged 2.09 mm. longer; this difference was

significant (3.06 times its probable error).

Group D Examined When 54 Days Old. Twenty-five White Leghorn, 30 Barred Plymouth Rock, and 40 Buff Orpington chickens were parasitized at 33 days of age each with 50 ± 5 embryonated eggs of Ascaridia lineata. Three weeks later the chickens were killed, the nematodes collected, counted and measured as in previous groups.

The White Leghorns had an average of 1.44 worms, while the Barred Rocks showed an average of 1.60 worms, a difference of 0.16 worm per chicken which was negligible. The average length of the worms from the White Leghorns was 19.94 mm., while that of those found in the Barred Rocks was 19.05 mm., a difference of 0.89 mm., which was not significant.

The Buff Orpingtons averaged 1.97 worms per bird, as compared with 1.60 worms found in the Barred Rocks, a difference of 0.53 worms, which was not significant. The worms from the Buff Orpington chickens averaged 18.22 mm. in length; those from the White Leghorns 19.94 mm., a small difference which lay within the limits of experimental error.

Comparison of the Barred Rocks, containing an average of 1.6 worms, with the Buff Orpingtons, possessing an average of 1.97 worms, showed a difference of 0.37 worm, which was not significant. The average length of worms from the

Barred Rocks was 19.05 mm., while that of the worms from the Buff Orpingtons was 18.22 mm. The difference was 0.83 mm. which was negligible.

When all of the results of Experiment 1 are considered, the Barred Rocks were the most resistant to the Ascaridia lineata, the White Leghorns the least resistant to the worms, while the Buff Orpingtons occupied a middle position in degree of resistance to the A. lineata.

Experiment 2

For Experiment 2 the chickens consisted of 50 White Leghorns, 65 Barred Plymouth Rocks and 60 Buff Orpingtons purchased as day-old chicks on January 15, 1934.

Group A Examined When 33 Days Old. When the chicks were 12 days old, they were banded and 12 White Leghorns, 24 Barred Plymouth Rocks and 25 Buff Orpingtons were each parasitized with 50 ± 5 embryonated eggs of Ascaridia lineata. At the end of three weeks the nematodes were collected in the usual manner and the data analyzed (Table 2).

A comparison of the number of worms found in the White Leghorns and in the Barred Rocks showed that the Barred Rocks contained an average of 2.28 worms less than did the other breed. The difference, however, was not significant. The White Leghorns carried worms which averaged 0.13 mm.

Table 2. Data on the comparative resistance of three breeds of chickens to the nematode Ascaridia lineata (Schneider) derived from Experiment 2.

Chickens	Number of Worms: Number of hosts	Average number worms per chicken	Standard deviation (O)	Error of mean	Actual difference of means (D)	Probable error of difference (P.E.D.)	Ratio, Act. mean dif. / P.E.D.x.666	Length of Worms: Average length of worms (mm.)	Standard deviation (O)	Error of mean	Actual difference of means (D)	Probable error of difference (E)	Ratio, Act. mean dif. / P.E.D.
Group A													
White Leghorns	12	3.42	3.22	0.627	2.28	0.951	2.39	21.95	8.15	0.859	0.13	0.97	0.13
Barred Rocks	24	5.70	5.20	0.716				21.82	7.81	0.45			
Buff Orpingtons	25	7.44	6.50	0.876	4.02	1.07	3.75	21.56	6.94	0.343	0.39	0.924	0.42
White Leghorns	12	3.42	3.22	0.627				21.95	8.0	0.859			
Barred Rocks	24	5.70	5.20	0.716	1.74	1.13	1.54	21.82	7.81	0.45	0.26	0.565	0.46
Buff Orpingtons	25	7.44	6.50	0.876				21.56	6.94	0.343			
Group B													
White Leghorns	12	3.92	3.03	0.59	0.67	0.858	0.78	20.98	6.8	0.616	0.42	0.820	0.51
Barred Rocks	20	3.25	4.14	0.624				20.56	5.57	0.465			
Buff Orpingtons	23	2.30	2.13	0.299	1.62	0.661	2.45	18.95	7.53	0.697	2.03	0.97	2.10
White Leghorns	12	3.92	3.03	0.59				20.98	6.8	0.676			
Barred Rocks	20	3.25	4.14	0.624	0.95	0.691	1.37	20.56	5.57	0.465	1.61	0.837	1.92
Buff Orpingtons	23	2.30	2.13	0.299				18.95	7.53	0.697			
Group D													
White Leghorns	26	1.0	1.10	0.147	0.19	0.244	0.78	17.81	6.7	0.886	3.08	1.35	2.28
Barred Rocks	21	0.81	1.33	0.195				14.73	6.3	1.03			
Buff Orpingtons	12	0.83	1.06	0.206	0.17	0.253	0.67	15.75	5.56	1.18	2.06	1.47	1.40
White Leghorns	26	1.0	1.10	0.147				17.81	6.7	0.886			
Barred Rocks	21	0.81	1.33	0.195	0.02	0.283	0.07	14.73	6.3	1.03	1.02	1.56	0.65
Buff Orpingtons	12	0.83	1.06	0.26				15.75	5.56	1.18			

longer than were those in the Barred Rocks, but this small difference was not a significant one. The Buff Orpingtons averaged 4.02 worms more than did the White Leghorns, giving a significant difference (Table 2). The difference in length of worms in the two groups of chickens was only 0.39 mm. This failed to be significant. The Buff Orpingtons showed an average of 1.74 more worms per bird than did the Barred Rocks. However, the difference was not significant. There was only 0.26 mm. difference in length of the worms, which was negligible.

Group B Examined When 40 Days Old. When the chickens were 19 days of age, 12 White Leghorns, 20 Barred Rocks, and 23 Buff Orpingtons were parasitized each with 50 ± 5 embryonated eggs of Ascaridia lineata. The nematodes were collected, counted and measured and the data analyzed.

The worms in the White Leghorns averaged 0.67 more in number than in the Barred Rocks. This was not a significant difference. The difference in length of worms found in the two breeds was 0.42 mm., which likewise was not significant.

The White Leghorns showed an average of 1.62 worms more than did the Buff Orpingtons, but this difference was not significant. Comparing lengths of worms, those from the Buff Orpingtons averaged 2.03 mm. longer than those in the White Leghorns, but owing probably to the small number

of hosts the difference was not significant.

When the worms from the Barred Rocks and the Buff Orpingtons were compared, the Barred Rocks were found to possess an average of only 0.95 worm more per bird. This was not significant. The average difference in length was 1.61 mm. which lay within the limits of experimental error.

Group D Examined When 54 Days Old. When the chickens had reached 33 days of age, 26 White Leghorns, 21 Barred Rocks, and 12 Buff Orpingtons were parasitized in the usual manner. The data were collected in due course and then analyzed.

The White Leghorns had 0.19 worm more than did the Barred Rocks. The difference in length of worms from the two breeds was 3.08 mm. Neither comparison was considered significant. The Buff Orpingtons and White Leghorns showed a difference in number of worms of 0.17 and a difference in length of 2.06 mm. These differences showed no significance (Table 2). The difference in number of worms in the Barred Rocks and Buff Orpingtons was only 0.02 worm and the difference in length 1.02 mm. Neither of these differences was significant.

While few of the differences in the various comparisons in Experiment 2 were significant, the results tend to support those of Experiment 1 in that slightly fewer and shorter

worms occurred in the Barred Plymouth Rocks than in either the Buff Orpingtons or in the White Leghorns. The latter in most instances had either more or longer A. lineata than did the Buff Orpingtons.

Results of Experiments 1 and 2 Combined

As Experiments 1 and 2 were performed in exactly the same way, using the same amount of embryonated eggs of the nematode and parasitizing groups of chickens of the same age, namely at 12, 19, and 33 days, the data from the two experiments were combined to obtain larger numbers of experimental animals and thus to make the results more reliable. The numbers of chickens of each breed in each age group were combined as were also the number of worms and the total length of worms. These data were then subjected to the biometric analysis.

Group A Examined When 33 Days Old. In Group A, 46 White Leghorns, and 36 each of Barred Plymouth Rocks and Buff Orpingtons were compared. The White Leghorns averaged 8.28 worms, while the Barred Plymouth Rocks averaged 9.22 worms, making an average difference of 0.94 worm per chicken. This small difference in number of worms was not significant. However, the worms from the White Leghorns averaged 22.08 mm. in length while those from the Barred

Plymouth Rocks averaged only 19.28 mm. long, making a mean difference of 2.8 mm. which was significant (Table 3).

The Buff Orpingtons had slightly more worms than did the White Leghorns (0.91 worm per chicken), a negligible difference. In length, the A. lineata from the Buff Orpington chickens averaged 22.44 mm. and those from the White Leghorns 22.08 mm., or an average difference of 0.36 mm. which was not significant. A comparison of the Barred Plymouth Rocks and the Buff Orpingtons showed that they differed only 0.03 in average number of worms; while in length of worms the difference was 3.16 mm., which was significant (Table 3).

Group B Examined When 40 Days Old. The combined group B contained 61 White Leghorns, 48 Barred Plymouth Rocks and 50 Buff Orpingtons. The White Leghorns averaged 7.34 worms and the Barred Rocks 3.71, making a mean difference of 3.63 worms, which proved to be significant (Table 3). Concerning mean length, that of the A. lineata from the White Leghorns was 18.19 mm. and that of the worms from the Barred Plymouth Rocks 16.78 mm., making a mean difference of 1.41 mm. which may have been significant (2.97 times its probable error).

The Buff Orpingtons showed a mean of 3.42 worms, which averaged 3.92 less than the White Leghorns. This was a significant difference (Table 3). In length the Buff

Table 3. The comparative resistance of White Leghorn, Barred Plymouth Rock and Buff Orpington chickens to the nematode Ascaridia lineata (Schneider). Data combined from Experiments 1 and 2. Chickens parasitized at 12, 19 and 33 days, respectively.

Combined experiments	Number of Worms: Number of hosts	Average number worms per chicken	Standard deviation (σ)	Error of mean	Actual difference of means (D)	Probable error of difference (P.E.D.)	Ratio, Act. mean dif. / P.E.D.	Length of Worms: Average length of worms (mm.)	Standard deviation	Error of mean	Actual difference of means (D)	Probable error of difference (E)	Ration, Act. mean dif. / P.E.D.
Group A													
White Leghorns	46	8.28	9.77	0.972	0.94	1.49	0.63	22.08	6.11	0.211	2.80	0.345	8.12
Barred Rocks	36	9.22	10.04	1.13				19.28	7.43	0.273			
Buff Orpingtons	36	9.19	10.53	1.18	0.81	1.52	0.60	22.44	6.56	0.243	0.36	0.322	1.12
White Leghorns	46	8.28	9.77	0.972				22.08	6.11	0.211			
Barred Rocks	36	9.22	10.04	1.13	0.03	1.63	0.02	19.28	7.43	0.273	3.16	0.365	8.66
Buff Orpingtons	36	9.19	10.53	1.18				22.44	6.56	0.243			
Group B													
White Leghorns	61	7.34	6.68	0.577	3.63	0.72	5.07	18.19	9.61	0.306	1.41	0.474	2.97
Barred Rocks	48	3.71	4.36	0.424				16.78	7.17	0.362			
Buff Orpingtons	50	3.42	4.67	0.446	3.92	0.73	5.38	17.38	8.12	0.418	0.81	0.518	1.56
White Leghorns	61	7.34	6.68	0.577				18.19	9.61	0.306			
Barred Rocks	48	3.71	4.36	0.424	0.29	0.62	0.47	16.78	7.17	0.362	0.60	0.552	1.09
Buff Orpingtons	50	3.42	4.67	0.446				17.38	8.12	0.418			
Group D													
White Leghorns	51	1.22	1.71	0.161	0.05	0.24	0.02	20.00	7.50	0.597	2.08	0.807	2.57
Barred Rocks	51	1.27	1.90	0.179				17.92	6.49	0.543			
Buff Orpingtons	52	1.71	2.74	0.256	0.49	0.302	1.62	17.94	7.77	0.555	2.06	0.815	2.52
White Leghorns	51	1.22	1.71	0.161				20.00	7.50	0.597			
Barred Rocks	51	1.27	1.90	0.179	0.44	0.312	1.41	17.92	6.49	0.543	0.02	0.776	0.0257
Buff Orpingtons	52	1.71	2.74	0.256				17.94	7.77	0.555			

Orpingtons showed worms averaging 0.81 mm. shorter than those found in the White Leghorns, a difference that was not significant.

A comparison of the number of worms from the Barred Plymouth Rocks and the Buff Orpingtons showed a difference of only 0.29 worm per chicken which was not significant. The worms from these two breeds in this group differed only 0.60 mm. in average length which was negligible.

Group D Examined When 54 Days Old. This group parasitized at 33 days of age contained 51 each of White Leghorns and Barred Plymouth Rocks and 52 Buff Orpingtons. An average of 1.22 worms was carried by the White Leghorns and a mean of 1.27 worms by the Barred Plymouth Rocks, a difference of only 0.05 worm per chicken. The worms from the White Leghorns averaged 20.0 mm. in length; those from the Barred Plymouth Rocks 17.92 mm. The difference of 2.08 mm. was not significant (Table 3).

The Buff Orpingtons averaged slightly more worms (1.71 per chicken), but a comparison between them and the White Leghorns showed that the difference was not significant. A comparison of the length of worms in the two breeds showed an average difference of 2.06 mm. which lay within the limits of experimental error. The Barred Plymouth Rocks and Buff Orpingtons showed an average difference in number

of worms of 0.44 per bird, which was negligible. In average length of worms the difference was only 0.02 mm.

Upon combining the data from Experiments 1 and 2, the outstanding result is the lower resistance of the White Leghorns to the A. lineata as compared with that of the Barred Plymouth Rocks and of the Buff Orpingtons. The degrees of resistance of the two latter and heavier breeds were approximately the same.

Age Resistance

A comparison of the number and length of worms found in the chickens of the same breed parasitized at different ages demonstrates whether or not the chickens become more resistant to the nematodes as the birds become older. Comparisons were made between chickens parasitized at 12 days and others of the same breed parasitized at 33 days of age. The older White Leghorns carried an average of 7.0 fewer worms than did the younger ones and the average length of the A. lineata was 2.08 mm. shorter in the older Leghorns. Both of these differences are considered significant; that on numbers of worms being strikingly so. The older Barred Plymouth Rocks showed an average of 7.95 fewer worms per chicken and worms averaging 1.36 mm. shorter than did the young Barred Plymouth Rocks. The number of worms is again strikingly fewer, but the difference in length was

too small to be considered significant. The two age groups of Buff Orpingtons showed a difference of 7.48 worms per chick and an average difference in length of worms of 4.5 mm. Both of these differences were considered significant.

The results of these comparisons indicate that an increase of age in chickens of the three breeds tested brings about an increase in the amount of resistance to the nematode. This resistance is displayed most clearly in the inability of the worm to become established or to retain its position in the digestive tract. To a lesser extent the length of the worms seems to be governed by the age resistance of the host.

DISCUSSION

Analysis of the experimental data on the comparative number of Ascaridia lineata from the different breeds as criteria of resistance indicates that the White Leghorn chickens were slightly less resistant to the nematode parasites than were the other two breeds. Why the average number of nematodes from the White Leghorns should be larger has not been ascertained. Records from individual birds in other experiments show a rather wide variation in the size of the infestations from chickens of the same parentage. This suggests an unknown factor that may control

the size of the infestation. The method of administering the nematode eggs might cause a chance variation. Sometimes the bits of filter paper and the eggs that were wiped upon them were allowed to dry for a few minutes before being placed into the oesophagus of the animal. In parasitizing, the bits of filter paper were picked up with medium-sized forceps, making it possible for some of the eggs to be crushed by the jaws of the forceps or to adhere to them. This would tend to reduce the size of the infestations. However, as the same method was used for all breeds, each would have the same chance of egg-loss in parasitizing.

In comparing the White Leghorns with the other two breeds as to length of worms harbored (Table 3), it is found that only once in six times were the worms shorter in the White Leghorn chickens. In this instance the difference was the least of any in the six cases. While the biometric analysis shows significant differences in only one of the comparisons of worm lengths, yet the consistently greater length of worms found in the White Leghorns leads to the conclusion that the White Leghorns provide a slightly more favorable environment for the nematodes.

Comparison of the Barred Plymouth Rocks and Buff Orpingtons showed that the latter had the longer worms in each case, although the difference in Group D was slight. How-

ever, in Group A the difference was significant.

In ranking the three breeds, the White Leghorns were the least resistant; the Buff Orpingtons assumed the mid-position and the Barred Plymouth Rocks showed the most resistance to the growth of Ascaridia lineata. Tests of larger numbers of chickens and especially of fowls from different flocks might change the relative degrees of resistance to parasitism displayed by these breeds.

Why the White Leghorns should be the most susceptible and the Barred Plymouth Rocks the most resistant is not known. It is conceivable that the greater age of the White Leghorn breed known early in Italy (Brown, 1929) might be a factor in the production of tolerance by the host to the parasite. The Buff Orpingtons which occupy a mid-position in resistance were subsequently known in England, whereas the Barred Plymouth Rocks which are somewhat the most resistant are, apparently, of the most recent origin, having been produced in America. Whether these or other factors are responsible for the differences in the breed resistance of the chickens to the large roundworm Ascaridia lineata remains to be proved.

SUMMARY

1. Two experiments involving 431 chickens were carried out to test the comparative resistance of White Leghorn, Barred Plymouth Rock and Buff Orpington chickens to the viability and growth of the nematode Ascaridia lineata (Schneider).

2. The chickens were divided into groups A, B and D which were parasitized at 12, 19 and 33 days of age, respectively. Each group consisted of about equal numbers of each of the three breeds. After the chickens had been parasitized for 21 days, they were killed and the nematodes collected.

3. The average number and length of worms from a group were used as criteria for judging the degree of resistance of the chickens to the parasites.

4. Comparison of the nematode infestations from the chickens 33 days of age with those from the fowls 54 days old showed that age resistance to the parasites developed in all three breeds.

5. The results of the experiments indicate that the White Leghorns were somewhat less resistant to the nematode than were the other two breeds. For example, the White Leghorn chickens of Group B had an average of 7.34 worms

apiece, while the Barred Rocks had a mean of 3.71 and the Buff Orpingtons 3.42 worms per bird. Most resistant to the nematodes were the Barred Plymouth Rocks. For example, in Group A the worms from the Barred Plymouth Rocks averaged 19.28 mm. in length, those from the White Leghorns, 22.08 mm. and the worms from the Buff Orpingtons, 22.44 mm. While many of the differences between average number and length of the worms from groups were not significant, the data demonstrate that the White Leghorns showed somewhat less resistance to the A. lineata than did the Barred Plymouth Rocks or the Buff Orpingtons and that of the three breeds, the Barred Plymouth Rocks were slightly the most resistant to the parasite.

6. The differences in breed resistance to the nematodes are attributed in part to a possible host tolerance in the White Leghorns or oldest breed. On this basis the newer breeds would be less susceptible than the Leghorns and hence more resistant to the A. lineata.

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